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Book of Abstracts
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Kellie Ann Beall, Editor

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Flammable Liquid Storerooms: Halon 1301 Replacement Program

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The Naval Research Laboratory's (NRL's) Center for Safety and Survivability has been actively investigating alternative fire suppression agents for Halon total flooding systems. A two phase program has been outlined to characterize the application of alternative gaseous clean agents in shipboard Flammable Liquid Storerooms (FLSRs). Information gathered from this program will be used as guidance in the design of future Navy ships. Two simulated shipboard FLSRs have been constructed at NRL's Chesapeake Bay Detachment (CBD). The compartment used for the first phase, FLSR 1, was designed to simulate a typical small shipboard compartment with dimensions of 3.05 m x 3.05 m x 3.05 m (28 m^3) (1000 ft^3). Phase 1 tests are serving as a learning process for designing and executing the FLSR phase 2 program. The phase 2 Large Scale Test Compartment (LSTC) with dimensions of 10.67 m x 6.10 m x 4.57 m (297.3 m^3) (10,500 ft^3), has been designed to simulate a large shipboard compartment. The compartment is currently being outfitted with the necessary instrumentation and is slated for testing in fiscal year 1999.

The agent evaluated under phase 1 was HFC-227ea, heptafluoropropane (HFP), the Navy's clean agent of choice. Limited Halon 1301 tests were also conducted for baseline comparison. The fire scenario was a cascading fire within the shelving from the upper level and a 0.30 m x 0.30 m deck pan fire, designed to simulate a cascading three-dimensional fuel spill forming a pool at the lower levels of the compartment. The fuel was 80% methanol and 20% *n*-heptane, with a total output of 200 kW. The fires were allowed to burn for a total of two minutes, the last 30 seconds with no ventilation, prior to agent discharge being initiated. After agent discharge, the compartment was kept sealed for a hold time period of fifteen minutes. Reignition of fires was attempted at predetermined times during the hold period and just after ventilation initiation. Continuous measurements of compartment temperatures and concentrations of agent, oxygen, products of combustion, and by-products of suppression were recorded during each test. Discrete (grab sample) measurements of agent, oxygen, carbon monoxide, and carbon dioxide gases were also taken at specific times at six locations.

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There is no place for complacency when dealing with energy rich combustion systems. During a baseline fire extinguishment test with HFP, an unexpected explosion occurred that was powerful enough to rupture two protective explosion vents. FLSR 1 is equipped with pressure sensitive relief vents because of the possibility of over pressurization occurring due to the dynamic nature of fires. The relief vents are 61 cm x 61 cm and are rated at a maximum release pressure of 0.14 kg/cm^2 each. The explosion was a result of fuel vapor dispersement caused by flows created at the time of agent discharge. Localized pockets of fuel vapor can be above the upper flammable limit, and will be mixed with air during discharge turbulence.

The phase 1 tests resulted in most fires being suppressed within 2 to 5 seconds from start of agent discharge, aided by a significant amount of oxygen depletion. The concentrations of the suppression by-product hydrofluoric acid (HF) were highest during reignition attempts due to the large flame sheet size and typically reduced agent concentration. Scrubbing of much of the HF was successfully achieved by the application of a Water Spray Cooling System (WSCS).[2]

The second phase of testing will be carried out in the LSTC outfitted to resemble a large shipboard flammable liquid storeroom. The volume of this compartment is significantly larger than FLSR 1, presenting a new set of parameters to evaluate. The larger compartment will use the same fire scenarios (i.e., cascading fire, pan fire, with a combined output up to 1 MW). Total fire suppressions, however, will not be as easily achieved. The fires in the compartment will be much more robust than in FLSR 1, creating different flow patterns within the compartment. The oxygen concentrations within the compartment will not be depleted as dramatically as with FLSR 1. Also, the construction of the shelving and mockups will present more obstructions throughout the compartment, restricting the flow patterns of the agent. The vertical height of the compartment is larger increasing the travel distance of the agent to the fire. The placement of the discharge system nozzles in the compartment will be essential in delivering the agent to the fire in an efficient manner. It is expected that since the fires will be more challenging to suppress, the time period for agent and fire interaction will increase. The concentrations of HF will be higher and will be characterized as to their impact on compartment reclamation procedures.

Evaluations are continuing in FLSR 1 with alternative technologies in addition to HFP studies. The results of testing in FLSR 1 and the LSTC will be used as guidance for designing the new Navy ship fire suppression systems. Critical system design information is needed. The scheduled testing is required to adequately characterize potential fire risks and gain a better understanding of the dynamics of the suppression in FLSRs.

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